

Claims

What is claimed is:

1. A fuel injector comprising:
an injector body defining a supply passage, a drain passage and a nozzle passage;
an admission valve that includes a valve member trapped to move between a drain valve seat and a supply valve seat;
said valve member being stoppable at a middle position out of contact with said drain and supply valve seats;
said supply passage being fluidly connected to both said nozzle passage and said drain passage when said valve member is in said middle position;
said nozzle passage being open to said drain passage but closed to said supply passage, when said valve member is in a closed position in contact with said supply valve seat; and
said nozzle passage being open to said supply passage, but closed to said drain passage, when said valve member is in a fully open position in contact with said drain valve seat.
2. The fuel injector of claim 1 including an electrical actuator attached to said injector body and including a movable portion; and
said valve member is operably coupled to move with said movable portion.
3. The fuel injector of claim 2 wherein said electrical actuator includes one of a solenoid and a piezo electric actuator.

4. The fuel injector of claim 1 wherein said drain passage includes an orifice with a flow area that is restrictive relative to a flow area across said drain valve seat when said valve member is in said middle position.

5. The fuel injector of claim 4 wherein said orifice has a circular cross-section with a diameter less than or equal to 1.5 mm.

6. The fuel injector of claim 1 wherein said injector body includes a plurality of nozzle outlets with a combined flow area that is restrictive relative to a flow area across said drain valve seat when said valve member is in said middle position.

7. The fuel injector of claim 1 including a first spring operably coupled to bias said valve member toward said closed position;

a second spring operably coupled to bias said valve member toward said closed position only when said valve member is between said middle position and said fully open position, and being inoperable to bias said valve member when said valve member is between said closed position and said middle position.

8. The fuel injector of claim 7 wherein said drain passage includes an orifice with a flow area that is restrictive relative to a flow area across said drain valve seat when said valve member is in said middle position;

an electrical actuator, which includes one of a solenoid and a piezo electric actuator, attached to said injector body and including a movable portion;
and

said valve member is operably coupled to move with said movable portion.

9. A fuel injection system comprising:
a common fuel rail; and
a plurality of fuel injectors according to claim 1 fluidly connected to said common fuel rail.

10. A method of injecting fuel, comprising the steps of:
injecting fuel at a low rate at least in part by stopping an admission valve member at a middle position out of contact with a drain valve seat and a supply valve seat;

injecting fuel at a high rate at least in part by stopping the admission valve member in a fully open position in contact with the drain valve seat; and

ending fuel injection at least in part by stopping the admission valve member in a closed position in contact with the supply valve seat.

11. The method of claim 10 wherein the step of injecting fuel at low rate includes a step of fluidly connecting a supply passage to both a drain and a nozzle passage.

12. The method of claim 10 wherein said injecting steps include the step of opening fuel flow from a fuel common rail to a fuel injector.

13. The method of claim 10 wherein the step of injecting fuel at a low rate includes a step of supplying low electrical energy to an electrical actuator; and

the step of injecting fuel at a low rate includes a step of supplying a high electrical energy to the electrical actuator.

14. The method of claim 10 including a step of coupling an admission valve member to move with a movable portion of an electrical actuator.

15. The method of claim 10 wherein the step of injecting fuel at a low rate includes restricting fuel flow in a drain passage downstream from a drain seat.

16. The method of claim 10 wherein the step of injecting fuel at a low rate includes a step of compressing one of a first biasing spring and a second biasing spring; and

the step of injecting fuel at a high rate includes a step of compressing both of the first and second biasing spring.

17. A fuel injection system comprising:

means for stopping an admission valve member in an injector body at a middle position out of contact with a drain seat and a supply seat to inject fuel at a low rate;

means for stopping the admission valve member at a fully open position in contact with a drain seat to inject fuel at a high rate;

means for stopping the admission valve member at a closed position in contact with a supply seat to end fuel injection.

18. The fuel injection system of claim 17 wherein said injector body includes an orifice in a drain passage that is restrictive relative to a flow area between said admission valve member and said drain seat when said admission valve member is in said middle position.

19. The fuel injection system of claim 18 including an electrical actuator, which includes one of a solenoid and a piezo electric actuator, with a movable portion; and

said admission valve member being operably coupled to move with said movable portion.

20. The fuel injection system of claim 19 including a common fuel rail fluidly connected to said injector body.